Application for Funds for the DØ Trigger

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Draft Version 2

(31 March 2000)

I. INTRODUCTION

Last year the PPESP agreed to make a contribution to the DØ experiment for the following parts of the upgraded detector:

Level 2 Silicon Track Trigger	£25,000
Level 3 Trigger Processors	£25,000
Unallocated	£10,000
Total	£60,000

Specifically, the funds for the Level 2 Silicon Track Trigger were approved for purchasing electronics cards for fitting tracks. The Silicon Track Trigger was recently fully funded by the NSF. We would like to transfer this funding from the track fitting cards to a different element of the Trigger system. In particular we would like to fund a set of boards designed to take the output of the Level 1 Central Fibre Tracker and prepare it for input into the Level 2 trigger. In the original DØ trigger design this task was to be carried out by a mechanical optical mixer device. Subsequent reviews of the design suggest that this task can be carried out much more effectively using an electronic mixer box. These boards are essential for the operation of the Level 2 trigger (including the silicon track trigger). We feel that we will make an even more significant impact on the experiment by funding the Mixer Box.

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We would also like to request an additional contribution so that the UK groups on the DØ experiment can fully fund this essential part of the experiment. The total cost of the Mixer boards is US$153,011 (£95,965) corresponding to an additional contribution of £60,965 from the PPESP. This small contribution to the experiment will ensure the successful completion of the trigger and help to ensure that the DØ experiment provides high quality physics results over the next five years. The total funding by PPESP for the DØ experiment would then be:

Mixer Boards	(allocated funding)	£35,000
Mixer Boards	(requested funding)	£60,965
Level 3 Trigger Processors		£25,000
Total		£120,965

In summary we request that the funds approved for the level 2 silicon track trigger be reallocated to the CFT Mixer boards, and request an additional £60,965 so that we can fully fund the Mixer Box.

II. CASE FOR SWITCHING PROJECT FUNDS

In January 1999 we requested funds to purchase electronics boards to fit tracks as part of the Level 2 Silicon Track Trigger (STT). At that time the STT had not been funded, and was not expected to be fully funded by the NSF. Subsequently, the STT was awarded a larger amount of funds than expected by the NSF and no longer needs a contribution from the UK for the track fit boards.

To reconstruct central tracks in the DØ trigger the output of the Central Fiber Tracker (CFT) has to be arranged into sectors in azimuthal angle ϕ that combine all of the layers of the detector. In the baseline design of the DØ upgrade the output from the CFT was to be rearranged into sectors in azimuthal angle ϕ with a physical mixer box. Over the last year the R&D needed to develop the physical connectors required for the mixer box showed that the efficiency of light throughput would be too low to provide the necessary trigger efficiency ($> 99\%$). In addition there is a high probability that the connector could be connected incorrectly leading to a loss of efficiency in the trigger.

An electronic Mixer Board has been designed to replace the physical mixer box, thus maintaining the efficiency of the CFT and reducing the possibility of connection errors. These electronic Mixer Boards are essential to the successful operation of all tracking triggers including the STT. Since the Mixer Boards are essential for the operation of the STT we feel that it is appropriate to transfer the funds allocated for the construction of Track Fit cards to the design and construction of the electronic Mixer Board. In addition to the funds previously allocated we request an additional £60,965 to fully fund the project.

The electronic mixer board is an essential part of all Level 2 central track triggers including the STT. As such it is an essential part of the trigger system and will have to be

funded. If we do not obtain funding for the project, DØ management will have to transfer the required funds from the funds provided by DOE for the trigger system. If the Mixer Boards are not funded then the forward electron pre-shower trigger will not be built.

If the forward electron preshower trigger is not built, then the DØ experiment will have to raise the p_T thresholds on electrons at large rapidities $\eta > 1$ from 5 GeV to 10 GeV at Level 1. At these rapidities we do not have a Level 1 Tracking trigger and rely on our calorimeter trigger. Without information from the forward preshower in the Level 1 framework we cannot reduce the QCD background to electrons. This effectively limits the off line E_T of forward electrons to be greater than 25 GeV. Hence we will not be able to trigger on forward J/Ψ which is essential for accurate energy calibration of forward electrons. This would effectively limit the acceptance of the DØ detector for electrons in high precision analyses such as the W mass measurement, the top quark mass measurement, for searches it reduces our acceptance for low-E_T multi-electron SUSY signals, and reduce the effectiveness the b-physics triggers.

If the Mixer Box was not built then DØ would not have a central track trigger at Level 2. The experiment would then have to rely on Calorimeter triggers for High p_T processes at central rapidities. This would severely limit all of the major physics goals of DØ. It would result in prescaled W and Z triggers, and inability to trigger on b-jets, reduce our sample of top events, and make a discover of the Higgs particle impossible.

We are not asking for the funds allocated for purchase of Level 3 processors to be transferred to the project as these funds are included in the DØ upgrade budget. If they were transferred then additional funds would have to found to replace the transferred funds leaving the budget.

III. DESCRIPTION OF THE MIXER BOARDS

I will rewrite the section, and include pictures.

The scintillating fibers of the Central Fiber Tracker, CFT, are arranged on the surfaces of eight barrels. These fibers are gathered into ribbons, each of which has two layers of 128 fibers. Each ribbon has a single connector to a clear-fiber light-guide. This light guide transmits the light to its cassette end where it is split into two 128-fiber connectors that plug into the top of a electronics readout cassette. Each Analog Front End, AFE, board therefore sees signals arranged by order of ϕ in each of the eight layers.

The trigger requires the fiber channels be arranged into trigger sectors, which are wedges of all eight layers (nine with the central preshower) in ϕ. The Mixer Box rearranges the output of the fiber channels from ribbons to trigger sectors. The mixer Box is currently being designed and built by Fermilab.

The ribbons are arranged on the detector into five-fold symmetry, and each of the five parts is called a Super Sector. The pattern of wave-guide bundles from each Super Sector is identical and the pattern of destination cassettes is identical. The routing of signals within each super sector is very complex.

The discriminated outputs from the AFE are multiplexed into groups of 140 bits per crossing. That's 20 bits per 53MHz-clock tick. These signals are input to one of 4 mixer boards (4 per super sector, 20 total) within the single mixer crate. After sorting, the signals are output, in groups of 189 bits per crossing, to the Digital Front End, DFE, boards.

There are two constraints on the mixer box. First, it must sort the signals from the orientation by ribbons to the orientation expected by the DFE boards. Second, it must add less than one crossing of latency to the trigger time. This second constraint is to insure that the track lists are received by the Muon L1 processors early enough to not delay their trigger decision time.

The mixing box sorts the signals in two steps. In the first step, the signals are exchanged over the back plane. In the second step, the signals are arranged by group for output to the DFE boards. Each of the four mixer boards has 17 input links, 15 for the CFT and 2 for the CPS.

The mixing box serves as a router, each input signal is routed to one unique output signal. On each 53MHz-clock tick 1/7th of the data arrives. And on average after 4 clock ticks that 1/7th is output to the DFE. But, only on average. Some of the signals, which are input on clock tick m, are output before the m+4th clock tick and some after. The non-repetitiveness of the geometry and the moving of signals from clock bins means that each of the signals for 1/5th of the detector must be treated separately. Thus, each of the 7,680 bits must be coded through the mixing box individually and by hand.

A. Cost Breakdown

This section describes the itemized costs of the electronic Mixing Box. All values are given in US dollars. A 20% contingency has been included and requested to cover possible cost overruns. The costs have been reviewed by the Lehman committee.

Item	Cost	Contingency	Total
Board Fabrication	13,000	2,600	15,600
Ivds Receivers/Drivers	8,778	1,756	10,534
CPLD Logic	59,211	11,842	71,053
Connectors	2,175	435	2,610
Misc. Logic	2,400	480	2,880
Assembly	6,600	1,320	7,920
Back Planes	6,000	1,200	7,200
Crate	3,000	630	3,630
Power Supply	800	160	960
Input Cables	14,960	2,992	17,952
Output Cables	10,560	2,112	12,672
Total	127,484	25,527	153,011

IV. SUMMARY OF DØ UPGRADE FUNDING

The DØ Upgrade has a total cost of US$46 million, the bulk of which is from DOE. The remaining US$1.5 million non-DOE funding is provided by NSF, India, France, and Russia. The total amount of foreign contributions is approximately US$1 million.

APPENDIX A: REPORT ON UK DØ ACTIVITIES: FEBRUARY 2000

Since the 3 UK groups joined the DØ collaboration last winter/spring we have made substantial progress towards fulfilling the goals which we described in our proposals to the PPESP [1,2] at that time. The highlights of the past year have been:

- A JREI award for a major DØ computing facility at Lancaster University (120 Dual-Pentium Processors, 1 TB of hard disk, a 24 TB tape robot, a fast Ethernet switch and a 2-year System Manager post);
- A PPARC "Responsive RA" award to Manchester University;
- A PPARC Advanced Fellowship award to Imperial College (Anna Goussiou);
- The appointment of a lecturer at Imperial College (Gavin Davies)
- A 3-day DØ Trigger Workshop at Imperial College attended by about 40 members of the collaboration from the USA and Europe - including 5 talks by UK physicists;
- Very significant contributions to the Level-3 Trigger track-fit and vertex finding software.

In addition, each group now has a resident Research Associate at Fermilab on LTA. This follows a very fruitful 6-month LTA by Ray Beuselinck in the first half of 1999. There are PhD students actively working on the experiment from all 3 groups.

The feedback from the collaboration about the Imperial College workshop was highly complimentary. Another workshop, on Physics Simulation, will be hosted by the Lancaster group (in the Lake District) during the summer of 2001.

UK based members of the collaboration are maintaining significant contact with the rest of the collaboration by regular visits to Fermilab and by using video-conferencing facilities.

REFERENCES

[1] Proposal for Imperial College and the University of Manchester to join the DØ Collaboration, PPESP Proposal 307 (November 1998).
Proposal for Imperial College and the University of Manchester to contribute to the Level 2 Track Trigger of the DØ Experiment, Addendum to PPESP Proposal 307 (January 1999).

[2]